broad and bearing a row of long slender spines on outer and inner margin. Uropod 2 bears only the outer ramus which is nearly as long as the peduncle; peduncle with a row of long slender spines on outer margin. Uropod 3 very short, extending very little beyond the telson, and bearing only a vestigial outer ramus armed with three long apical spinules. Telson broader than long, somewhat truncate distally and bearing a seta on either lateral margin. Length of male from front of head to end of uropods 5 mm.

Female.—The female is like the male except that the antennae and first gnathopod are not quite so strong. Gnathopod 1 is much like that of the male, but the palm is more oblique, less sinuous and is not defined by a lobe. Length of female from front of head to end of uropods about 4 mm.

Type.—A male selected from several found in the stomachs of haddocks, nos. 58 and 62, taken by A. W. Needler in the Bay of Fundy.

Five females were taken by the steamer *Speedwell* (no. 141) in Gloucester Harbor, Mass., August 1, 1878, in 8.5 fathoms, and one male was taken by the *Speedwell*, no. 321, lat. 42° 03′ N., long. 70° 15′ W., in Cape Cod Bay, Mass., August 30, 1879, in 29.5 fathoms.

ZOOLOGY.—*Four new species of the acanthocephalan family Neoechinorhynchidae from fresh-water fishes of North America, one representing a new genus.*[1]

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In previous publications (Van Cleave, 1945, 1947, and in press; and Van Cleave and Manter, 1948) it has been demonstrated that speciation in the Acanthocephala has been significantly associated with speciation of fish hosts, particularly in North America. This parallel in evolutionary progress of parasites and their hosts has been especially conspicuous in the family Neoechinorhynchidae (class Eoacanthocephala, order Neoacanthocephala). In this family diversification of its members has attained two entirely different levels. At the lower of these, by purely quantitative changes in the pattern of structure, distinctive species have evolved, while at the higher level differentiation of the parasites has gone so far that completely new qualitative features have become established. As a consequence, these forms are no longer recognizable as belonging to the original parent genus, since they have attained new structural expressions in features which taxonomists recognize as capable of reflecting generic differences. At the level of specific differentiation, the genus *Neoechinorhynchus* has undergone explosive speciation in the North American fauna so that at the present time ten species of this genus are known in the literature for this continent and three more are to be added in the present contribution.

[1] Received July 7, 1949.

At the generic level the differentiation of the Neoechinorhynchidae along with the evolution of the American fish fauna has resulted in the establishment of five distinctive genera previously recognized in the literature. These are *Octospinifer* in Catostomidae, *Eocollis* in Centrarchidae, *Atactorhynchus* in *Cyprinodon*, and *Gracilisentis* and *Tanaorhamphus* in *Dorosoma*. To these is herein added the sixth distinctively North American genus of the Neoechinorhynchidae —*Paulisentis*, which occurs in the creek chub, *Semotilus atromaculatus atromaculatus* (Mitchill). *Paulisentis fractus*, genotype of the newly recognized genus, has been found in a very localized portion of the broad geographical range of the host species, in Wayne County, in the north-central part of Ohio.

At the specific level of differentiation, the three new species of the genus *Neoechinorhynchus* named and described in this paper include an additional distinctive species, *N. saginatus*, characteristic of the creek chub in Wisconsin; *N. tumidus*, apparently restricted to ciscoes and whitefishes of the Northern States and Canada as definitive hosts; and *N. doryphorus*, a peculiarly modified member of the genus as yet known from a single species of definitive host from Florida.

With the exception of some of the material of *N. saginatus* collected by J. Fischthal and some of the specimens of *N. tumidus*

taken by other collectors, all the specimens that serve as basis for the new species here described have been collected by Bangham in the course of parasite surveys in Ohio, Florida, and Wisconsin.

It is rather remarkable that within a single host species, the creek chub, both the generic and the specific levels of differentiation of its parasites in the Neoechinorhynchidae have been attained. Each of these species seems to be rather definitely limited in its geographical distribution, and although extensive field studies have been made there is as yet no evidence that the two species ever occur in the same locality. The only other instance of a distinctive North American fish with two distinctive species of Neochinorhynchidae is that of *Dorosoma cepedianum* (LeSueur) with its *Gracilisentis gracilisentis* (Van Cleave) and *Tanaorhamphus longirostris* (Van Cleave). Not only do these occur in the same locality, but it has been shown (Van Cleave, 1916, p. 109) that each occupies a seasonal ecological niche within the intestine of *Dorosoma*. At present there are no facts available to explain why the two species of Neoechinorhynchidae adapted to the creek chub have failed to extend their respective geographical distributions beyond their present limits.

Paulisentis fractus has been found in the creek chub in Ohio but never in any other part of the range of the chub, while *Neoechinorhynchus saginatus* occurs in the same host only in Wisconsin. Extensive field surveys in both Wisconsin and Ohio have failed to give evidence that either species of the chub parasites occurs in other vertebrate hosts that might be the normal hosts with the chub, in either instance serving as accidental host of a species normally adapted to a different host species.

The hypothesis that evolutionary changes in the host are accompanied by correlated evolutionary changes in the parasite here appears to lack the obvious support which it receives in some other instances. It seems self-evident that the two different acanthocephalan species of the creek chub probably originated from different ancestral stocks rather than from a common species which was resident in the intestine of the ancestors of the present day chub throughout its geographical range. Available facts give no conclusive evidence as to the lines of descent of the present day parasites of the chub.

It is very unusual for two such diverse species of Acanthocephala to be established in a single host species in a condition of apparently rather strict host specificity while each occupies but a very restricted portion of the geographical range of that host. One of the most obvious explanations might be that each species of the parasite has as an essential intermediate host some species of arthropod whose geographical distribution is distinctly limited. Yet another possible explanation is that in the case of either or both of the species of parasites the chub may be an incidental or accidental definitive host, while some other species of vertebrate, as yet undiscovered, may be the normal host for the parasite.

Within a single host species clearly different levels of diversification of its acanthocephalan parasites may occur. This observation leads to the conclusion that the extent of modification of the fish host does not find direct, quantitative expression in the extent of the modifications of its parasites.

An appreciation of the wide dispersal of *Semotilus atromaculatus atromaculatus* is gained in the following quotation from Hubbs and Lagler (1941, p. 53): "From Montana and from the Red River of the North drainage to the Gaspé Peninsula in Canada, southward on both sides of the Appalachians to Georgia and other Gulf States, southwesterly to the Ozark Upland and the Arkansas and upper Pesos river systems in New Mexico." Over such a broad expanse of territory the fish encounters highly diversified physical and biological environments which seem to have had no direct effect upon producing variability in the fish. In many parts of its geographical range the creek chub is apparently entirely free from acanthocephalan parasites.

In North America, speciation within the genus *Neoechinorhynchus* has been extremely active and the genus has become highly diversified (Van Cleave, in press) to the extent that many fish hosts have their own distinctive species, although the adaptations between parasite and host often permit of more than a single host species. Similarity in food habits often seems to be more important in expanding host relations than

mere blood relationship of the vertebrate hosts although conditions become pyramided in the expansion of host relations when closely related species of fish have identical food habits. Specific adaptations between some members of the genus *Neoechinorhynchus* and peculiar North American fishes and wide host tolerance of others combine to produce contradictory impressions which introduce many difficulties into the recognition of the species of *Neoechinorhynchus* encountered in surveys of fish parasites. The genus is so distinctive that recogtion at the generic level is easily assured on features of general morphology. However, specific identification is often impossible in field studies and must await detailed measurements and comparisons even when intangible evidences seem to set specimens apart as different from all the species previously recognized.

The authors of the present paper have, on numerous occasions, encountered specimens of Neoechinorhynchidae that could not be identified at once. In preliminary reports, these have often been referred to as *Neoechinorhynchus* sp. (Bangham, 1940, p. 299; 1941, p. 163, 164; 1946, p. 321). Several of these undetermined species have been studied critically along with other unidentified specimens from Canada and from the Eastern United States, and in many instances further field studies have been made specifically to secure additional specimens of the critical material for study. In addition to the distinctive *Paulisentis fractus*, three additional species of *Neoechinorhynchus* are being described in this paper. Several other species remain unnamed and undescribed in the authors' collections, pending the discovery of better or more adequate material to justify their diagnosis.

Paulisentis, n. gen.

Diagnosis.—With the characters of the family Neoechinorhynchidae. Proboscis small, shortly cylindrical, provided with relatively weak hooks arranged, not in perfect circles and longitudinal rows but as six diagonal rows of five hooks each. Body wall relatively thick. Musculature of male bursa poorly developed. Parasitic in the intestine of fresh-water fishes. Development unknown.

Type species: *Paulisentis fractus*, n.sp.

Paulisentis fractus, n. sp.

Figs. 1–5

Description.—With the characters of the genus *Paulisentis*. Body short, very broad, without marked attenuation at either extremity, terminating bluntly (Figs. 1, 2). Females (Fig. 1) 2.3 to 4 mm long, with maximum width of about 0.6 to 0.8 mm. Body wall often 0.079 to 0.132 mm in thickness. Proboscis (Figs. 4, 5) 0.093 to 0.105 mm in width and 0.089 to 0.120 mm in length. Males (Fig. 3) 1.4 to 2.86 mm long by 0.410 to 0.620 mm wide. Proboscis but very slightly smaller than in female.

Proboscis hooks (Figs. 4, 5) minute, not conspicuously different in the two sexes; not in perfect transverse and longitudinal rows but in approximately six diagonally spiral lines of five hooks each, making a total of about 30 hooks on the entire proboscis instead of the 18 distinctive of the genus *Neoechinorhynchus*. Hooks near tip of proboscis 24 to 27μ long; in middle region 19 to 27μ; at base 11 to 16μ; the largest hooks from 4 to 6μ in diameter at the bend where thorn and root join. Root processes never conspicuous, poorly defined.

In some males the genital organs (Fig. 3) extend practically the entire length of the trunk; the two testes in broad mutual contact and cement gland (C) broadly joined to the hind testis (T). Anterior testis often touching the posterior end of the proboscis receptacle. Cement gland somewhat shorter than either testis.

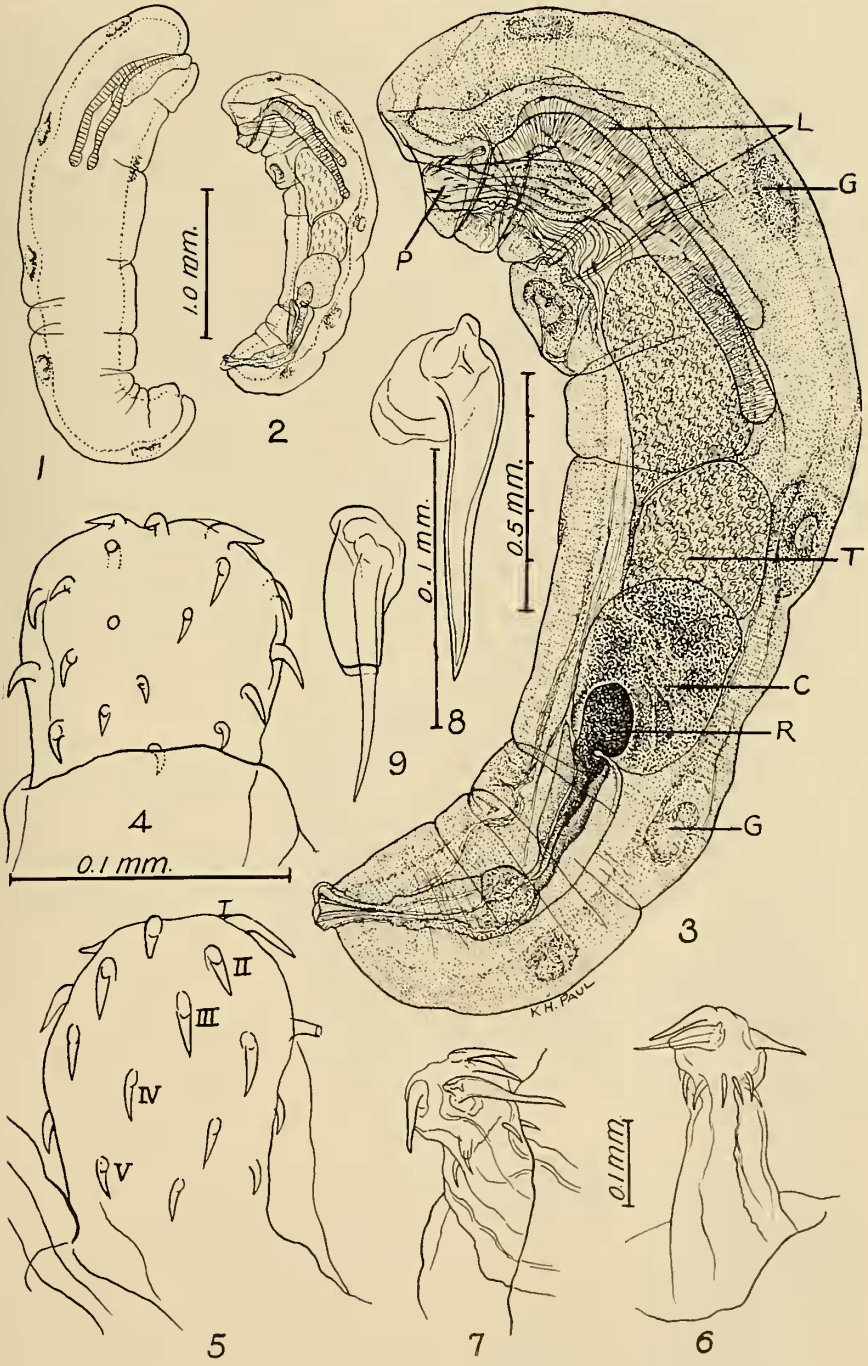
Lemnisci (L), when fully extended, usually reaching to the interval between the second and third dorsal subcuticular giant nuclei. Nuclei of the lemnisci not distinguishable in available material.

Shelled embryos within body cavity of gravid female 35 to 38μ long by 11 to 14μ wide. Development wholly unknown.

Definitive host.—*Semotilus atromaculatus atromaculatus* (Mitchill), the creek chub from streams in Wayne County, Ohio, collected by R. V. Bangham.

Type material.—Holotype male, U.S.N.M. Helm. Coll. no. 37128. Allotype female (VC 3713.1) and series of paratypes representing both sexes in the collection of H. J. Van Cleave, Urbana, Ill., and paratypes in the collection of R. V. Bangham, Wooster, Ohio.

In all the specimens available for this study, at least the base of the proboscis was retracted



Figs. 1–5.—Morphological details of *Paulisentis fractus*, n.g. and sp.: 1, 2, Outline drawings showing characteristic body form of paratype female (1) and holotype male (2) and relative size and shape of the two sexes; 3, analytical study of morphology of holotype male; 4, 5, typical proboscides when dissected from their retracted position within front end of trunk.

Figs. 6–9.—Morphological details of *Neoechinorhynchus doryphorus*, n.sp.: 6, 7, Proboscis and its attachment to trunk, viewed from opposite lateral surfaces to show disparities in lateral hooks of terminal series; 8, 9, detail showing form and structure of the two highly modified lateral hooks.

within the front end of the trunk (Fig. 3), and in many the entire proboscis was completely obscured by retraction. The delicate hooks could not be measured nor could their arrangement be determined with accuracy in retracted individuals. The writers are particularly indebted to Mrs. Jean A. Ross for skillfully dissecting out the minute proboscis from many of the worms and making stained permanent mounts of the dissected parts. Without these mounts the details of the proboscis and its hooks could not have been determined.

Since the genus *Paulisentis* is monotypic, the comparisons of *P. fractus* must be confined to species of other genera of the Neoechinorhynchidae. The presence of more than three circles of proboscis hooks very distinctively sets it apart from all species of the genera *Neoechinorhynchus*, *Octospinifer*, *Eocollis*, and *Gracilisentis*, which are all characterized by the rigorous imposition of a hook formula invariably involving three circular rows. The genera *Atactorhynchus* and *Tanaorhamphus* are the only North American members of the family having more than three circles of hooks. From *Atactorhynchus*, *P. fractus* is easily distinguishable through differences in form of the body, extent of the male genital organs and number and arrangement of the proboscis hooks. From the two described species of *Tanaorhamphus*, *P. fractus* differs in the shape and size of the proboscis and number of its hooks and shape of the body.

Neoechinorhynchus saginatus, n. sp.

Figs. 12–25

In the course of extensive surveys of parasites of fishes of Wisconsin, large numbers of an undetermined species of the genus *Neoechinorhynchus* were discovered in the intestine of the creek chub (*Semotilus atromaculatus atromaculatus*) by R. V. Bangham and by J. Fischthal. Materials from both of these studies have been available for study and on these collections is based the description of *Neoechinorhynchus saginatus*, n.sp., a form with very prominent sexual dimorphism. Measurements of the proboscis and its hooks, features which are so readily available for differentiating the various species of *Neoechinorhynchus*, seemed to justify the assumption that these specimens from the chub in Wisconsin might belong to *N. rutili* (Müller) a species which has recently been determined for the American fauna in a paper now in press (Van Cleave and Lynch). However, a glance at a series of the specimens gave absolute proof that in reducing the comparisons to a few selected features some differences of distinctive nature were being disregarded (cf. Figs. 10 and 11 with 12 and 13). General shape of the body, position of the proboscis in its relations to the trunk and size of the male reproductive organs in comparison with the body size are all features that add support to the distinctive body sizes of the two sexes in the material from the creek chub.

An extensive study of *N. rutili* has revealed (Van Cleave and Lynch, in press) that females of that species never exceed a length of 10 mm. This limit in size is likewise recorded for the European representatives of the same species by Meyer (1932; p. 172). Consequently, when females in chubs were found often between 15 and 20 mm in length, it seemed obvious that such discrepancy in size adds its support to the distinctive though minor morphological features and specific host relationship. Although the material from the chub was taken from the same regions where *N. rutili* was established in other hosts, the latter was never recognized in chubs nor was

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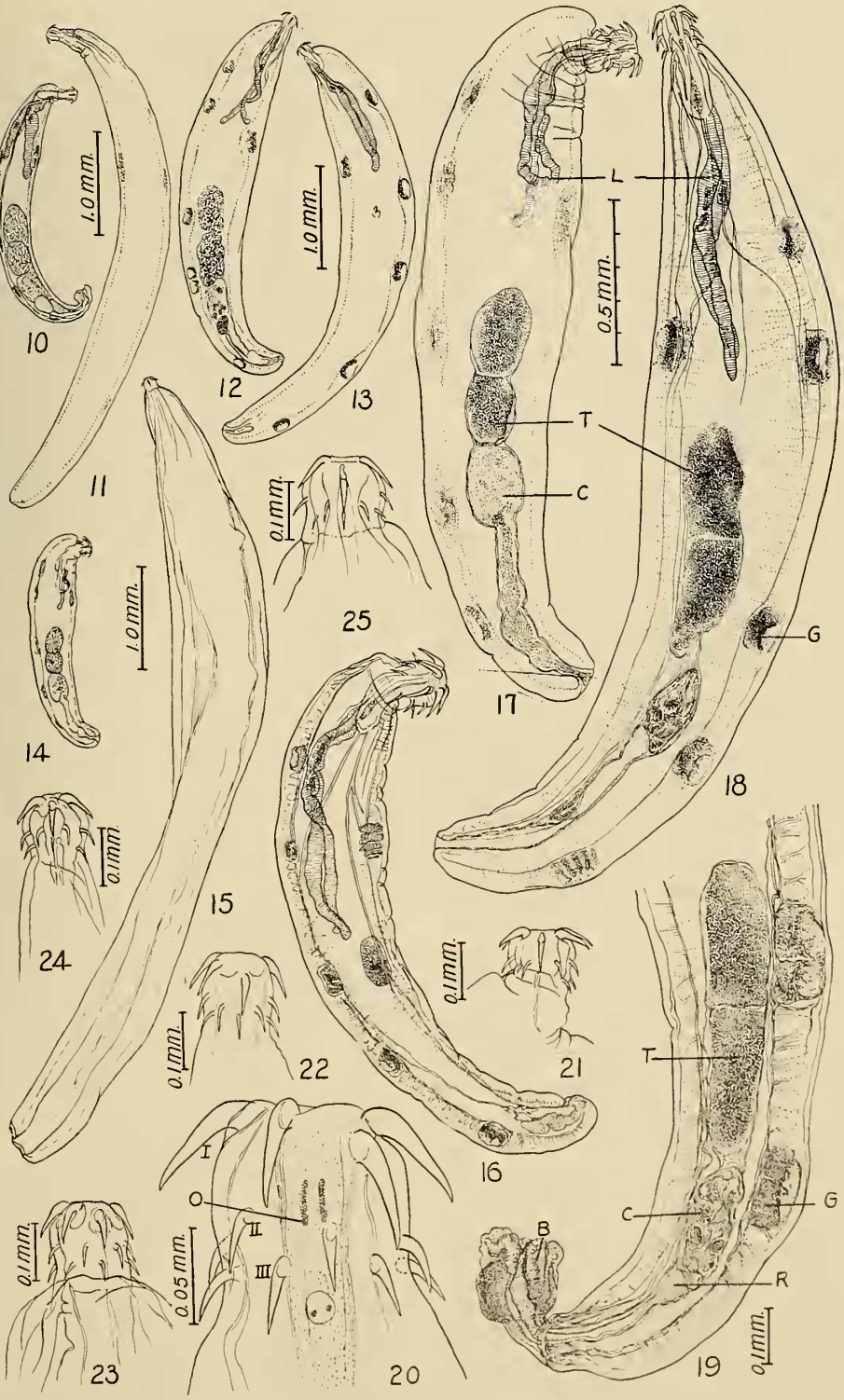
Figs. 10–25.—Morphological features of *Neoechinorhynchus saginatus*, n.sp., and comparison with general appearance of *N. rutili* (Müller): 10, 11, Male and female of *N. rutili* showing relative size of typical individuals of the two sexes and general proportions for body of each (note that female, Fig. 11, is of about maximum size for this species); 12, 13, male and female of *N. saginatus* showing distinctive difference of body shape from that of *N. rutili*, the female (Fig. 13) a very young immature individual; 14, 15, characteristic male and female of *N. saginatus* from intestine of same specimen of creek chub, showing prominent sexual dimorphism, especially in size, the female (Fig. 15) considerably below average maximum size for females of this species (a female of near maximum size from same host individual if drawn to same scale would be half again longer than entire length of this plate); 16, juvenile female of *N. saginatus* from intestine of a creek chub, before the egg balls have formed; 17, 18, typical males of *N. saginatus* showing topography of genital organs (in Fig. 18 the testes have already begun to break up); 19, posterior extremity of male of *N. saginatus* with copulatory bursa partially extruded; 20, proboscis of female of *N. saginatus* greatly enlarged to show characteristic arrangement of the two elongated and a single spherical nucleus in the distinctively elongated terminal organ of proboscis; 21–25, individual variation in size and appearance of proboscis of *N. saginatus*, all drawings to same scale.



FIGS 10–25.—(See opposite page for explanation).

the new species, *N. saginatus*, ever found in other fishes.

Description.—With the characters of the genus *Neoechinorhynchus*. In fully grown individuals showing extreme sexual dimorphism in size (cf. Figs. 14 and 15). Body more nearly robust than cylindrical, with relatively thick body wall. Females often attaining a length of 20 mm, with a diameter of 1.25 to 2.1 mm in large, gravid females, in the vicinity of the second dorsal or the ventral giant subcuticular nucleus; posteriorly tapering gradually; anterior extremity somewhat enlarged, often with a slightly humpbacked appearance (Figs. 12, 17) in the region where the trunk reduces to join the neck and proboscis. Proboscis usually emerging from near the ventral margin of the anterior extremity of the trunk and rarely standing at a conspicuous angle to the body axis. Proboscis commonly 105 to 119μ long by 79 to 132μ wide. The hooks of the terminal circle usually 58 to 67μ long with a diameter of 16μ at the point where the thorn joins the root. Hooks of middle circle 31 to 38μ long; of basal circle 27 to 32μ long. Males diminutive when compared with fully grown females (cf. Figs. 14 and 15) commonly not more than 8 mm with a maximum diameter of from about 0.7 mm to 1.4 mm. Proboscis and its hooks not appreciably different from those of female. Male genital organs occupy only about the posterior half of the body cavity and are regularly of less diameter than the width of the body cavity. Hard shelled embryos within gravid females 44 to 46μ long by 16 to 20μ wide.

Type host.—*Semotilus atromaculatus atromaculatus* (Mitchill) in streams and lakes of Wisconsin.

Type material.—Holotype male (U.S.N.M. Helm. Coll. no. 37130) and allotype female (U.S.N.M. Helm. Coll. no. 37131). Paratypes in collection of H. J. Van Cleave, Urbana, Ill., and in collection of R. V. Bangham, Wooster, Ohio.

Remarks.—*N. saginatus* is morphologically nearest to *N. rutili*, from which it differs especially in proportions of the body. These differences are most readily appreciable through comparison of Figs. 10 and 11 with Figs. 12 to 14. The proboscis hooks of the terminal and middle series in *N. saginatus* tend to be smaller than those of *N. rutili* but there is so much variability in the latter that some individuals are found in which this difference is not a valid basis for separating the species. The embryos of *N. saginatus* are usually considerably longer (44 to 46μ) than those of *N. rutili* (30 to 40μ).

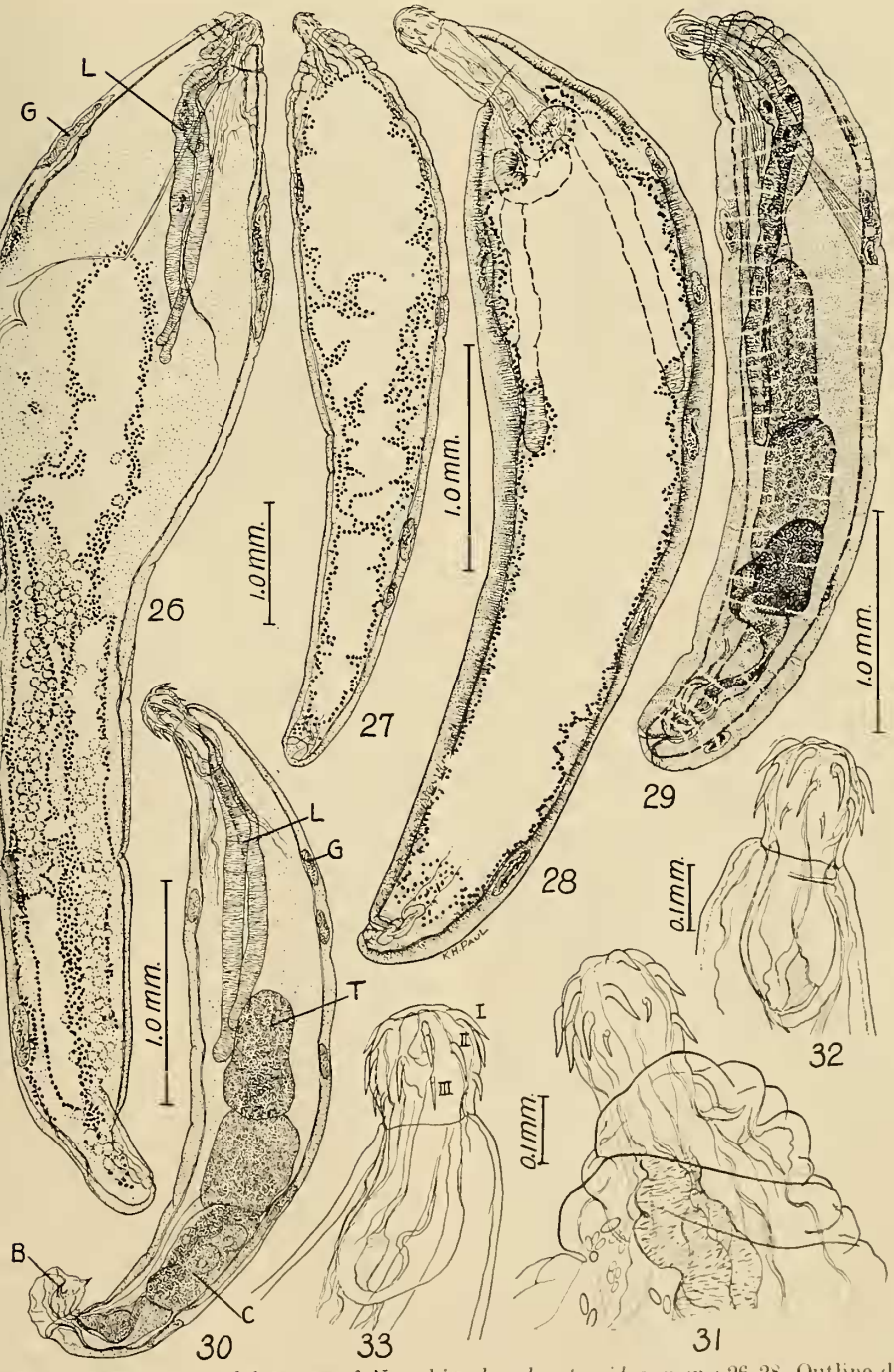
Neoechinorhynchus tumidus, n. sp.

Figs. 26–32

There have been but few instances of Acanthocephala reported from ciscoes and whitefishes of North America. Most of the recorded instances are of apparently accidental infection by species of Acanthocephala common in other fishes of the habitat under consideration. In America, *Echinorhynchus coregoni* Linkins is a common species that seems to have normal association with fishes of the genus *Coregonus*, but in most habitats several other species of fishes seem to serve equally as hosts for this parasite. In Europe, the records of whitefishes similarly consist of a long list of species of Acanthocephala all of which have wide host adaptations. Ciscoes and whitefishes are largely plankton feeders; hence it is not surprising that they fail to show as great consistency in their acanthocephalan parasites as are the fishes that select larger arthropods as food or are of predacious habits.

Parasite surveys have previously demonstrated that heavy infections by worm parasites occur especially in those fishes that feed in shallow waters and particularly in weed beds where intermediate arthropod hosts are brought into intimate and prolonged association with infected fishes. General infection of susceptible arthropod hosts by larval acanthocephalans is thus assured and these same arthropods transmit their parasites back to fishes that feed upon them. In contrast, fishes that are predominantly plankton feeders are not intimately associated with the free-floating plankton organisms, consequently the opportunity for the arthropods to become generally or heavily infected with Acanthocephala is much reduced. Thus the plankton arthropods cannot transmit back to the fishes that feed upon them as heavy or as general infections as are carried back to the fishes that inhabit and regularly feed in shallow waters.

In a number of surveys of fish parasites made in the United States and Canada, the whitefishes and ciscoes have been found free from acanthocephalan parasites peculiar to them (Van Cleave and Mueller, 1934; Bangham and Hunter, 1940; Bangham, 1946). In keeping with the statements made above, in some localities infections with *Leptorhynchoides thecatus* (Linton) have been



Figs. 26–33.—Morphological features of *Neoechinorhynchus tumidus*, n.sp.: 26–28, Outline drawings of mature paratype females showing characteristic inflation of forepart of trunk and distinctive shape of region where inflated trunk becomes reduced to join neck and proboscis (28) (in all this series the extent of the developing eggs filling the body cavity is shown schematically without attempt to indicate individual eggs and embryos); 29–30, morphological details of paratype males showing individual variation in body shape, Fig. 29 from Waskesin Lake, Saskatchewan, and Fig. 30 from same host species of Trout Lake, Wis.; 31–33, proboscis and its attachment to neck and trunk—Fig. 32 is of holotype female, Figs. 31 and 33 are of paratype individuals.

reported (Bangham, 1941) and heavy infections of *Echinorhynchus coregoni* have been encountered (Bangham and Hunter, 1939). Unpublished records of the occurrence of light infections of *Pomphorhynchus bulbocolli* are likewise available. All three of these are well known and easily recognizable species. Therefore when specimens of a distinctive species of *Neoechinorhynchus* were found in considerable numbers in two different northern localities they aroused immediate interest. A careful study and comparison of these specimens with all known species of Europe and America has demonstrated that they represent a previously unrecognized species which is here described under the name *Neoechinorhynchus tumidus*, n. sp.

In the period from 1928 to 1930, D. S. Rawson made collections of fish parasites from various lakes in the Canadian province of Saskatchewan. He submitted these specimens to the late Prof. Henry B. Ward, who gave the Acanthocephala from ciscoes and whitefishes to one of us (Van Cleave) for identification. Later, specimens from the same hosts were encountered in the extensive surveys of parasites of Wisconsin fishes by Bangham. The latter proved to be identical with the specimens from Saskatchewan and have made possible a fuller analysis of the species than could have been drawn on the basis of the material from Canadian collections alone. Although there are negative records for normal hosts from many localities in Canada and Northern United States, it is probable that *N. tumidus* may have broad geographical distribution in these areas.

Description.—With the characters of the genus *Neoechinorhynchus*. Body of female showing a distinct inflation in the anterior region (Figs. 26, 28). Females having a length of 4 to more than 12 mm, when somewhat compressed in mounting having a maximum diameter in the inflated region of 0.87 to 2.5 mm, rapidly reducing anteriorly to a diameter of about 0.3 to 0.4 mm at the juncture of neck and trunk and posteriorly diminishing to a subcylindrical taillike termination usually under 0.5 mm in diameter. The genital pore commonly a short distance from the posterior extremity (Fig. 26) at the base of a slight postgenital protuberance. Body of males (Figs. 29, 30) shortly cylindrical, lacking anterior inflation characteristic of the females, commonly 3 to 5 mm long with a maximum diameter of 0.7 to 1.5 mm. Neck short, about 40 to 80μ long, an unmodified truncated cone. Proboscis of female (Figs. 31, 32) 172 to 210μ in diameter by 132 to 172μ in length. Terminal hooks 75 to 84μ long with a diameter of 16 to 19μ; hooks of middle circle not conspicuously smaller than those of terminal series, 67 to 79μ, commonly with a slightly sigmoid outward reflection of the point; basal hooks 45 to 53μ long. Proboscis of male slightly smaller than that of female, 158 to 172μ in diameter by 119 to 154μ long. Terminal hooks 69 to 84μ (16–19μ in diameter). Median hooks 67 to 79μ; basal hooks 40 to 53μ. Male genital organs occupy more than one-half the length of the body cavity. Testes and cement glands (Figs. 29, 30) in broad mutual contact; the lemnisci often reaching the level of the posterior testis. Hard-shelled embryos within body cavity of gravid females 36 to 40μ long by 16 to 19μ in width.

Hosts.—In intestine of *Leucichthys artedi* (LeSueur) of Trout Lake, Wis., and of Waskesin Lake, Saskatchewan, Canada, and *Coregonus clupeaformis* (Mitchill) of Waskesin Lake.

Type material.—All material prepared as stained permanent mounts on slides. Holotype female and allotype male from *Leucichthys artedi* (LeSueur) of Trout Lake, Wis. (VC 3812), collected by R. V. Bangham. Paratypes from the same host and same locality as well as from Lake Waskesin, Saskatchewan, Canada, collected by D. S. Rawson in *Leucichthys artedi* (VC 2387) and *Coregonus clupeaformis* (Mitchill) (VC 2390). Holotype and allotype deposited in United States National Museum (Helm. Coll. nos. 37133 and 37134). Paratypes in collection of H. J. Van Cleave, Urbana, Ill., and in that of R. V. Bangham, Wooster, Ohio.

Remarks.—In fully mature females of *N. tumidus*, the anterior region of the trunk is more inflated than in any other species of the genus and is conspicuously distinguishable from the narrowed posterior region of the trunk (Figs. 26–28). The proboscis of *N. tumidus* is smaller than that of *N. crassus* but it is distinctly larger than that of *N. cristatus*, *N. venustus* and *N. rutili*. From species with proboscis of similar size, that of *N. tumidus* is most readily distinguishable by the fact that the hooks of the second series are not conspicuously smaller than those of the terminal series. Usually the hooks of the second series are slightly sigmoidal with the point curved outward away from the proboscis wall.

Neoechinorhynchus doryphorus, n. sp.

Figs. 6–9

When asymmetry in arrangement of the proboscis hooks occurs in the Acanthocephala, it most often finds expression as dorsoventral differentiation of the pattern (Van Cleave, 1941). For the genus *Neoechinorhynchus* most investigators have assumed (Van Cleave, 1939) that radial symmetry is the fixed rule for most species. As early as 1904, Lühe (p. 191) called attention to the fact that the hooks of the so-called terminal circle on the proboscis of *N. rutili* (= *E. clavaeceps*) are actually arranged in two levels, but he was in serious error when he expressed the belief that this constituted a pattern of two circles of three hooks each. Not all species of *Neoechinorhynchus* show this differentiation of the terminal hooks satisfactorily. For *N. emydis* (Leidy), Lincicome (1948) clarified this matter by demonstrating that a single hook on each of the two lateral surfaces of the proboscis is set somewhat posterior to the point of attachment of the two ventral and the two dorsal hooks of the same series. He further emphasized the fact that the two lateral hooks in *N. emydis* are somewhat longer and distinctly heavier than the dorsal and ventral members of the terminal series. These observations constitute the only instance in the Acanthocephala wherein the lateral hooks are distinctively larger than the dorsal and ventral hooks of the same series. A similar distinction has been observed in a few species of the genus *Neoechinorhynchus* from fishes but the degree of difference is usually not as pronounced as observed in *N. emydis* and becomes evident only when the proboscis is mounted so that it can be viewed in full end view since only in such mounts may adjacent hooks be viewed at the same time, without change of focus to disturb the impressions of relative size.

In southern Florida, Bangham (1940, p. 298) discovered an undetermined species of *Neoechinorhynchus* in the flagfish (*Jordanella floridae* Goode and Bean). A study of this material has revealed that the lateral hooks of the terminal series on the proboscis show a degree of differentiation that has been previously unknown for any member of this genus. Not only are the lateral hooks larger and longer than the dorsal and ventral members of the same series, but the right and the left hooks show an extreme expression of asymmetry. One of the laterals (apparently the right) is extremely long and heavy (Fig. 8) while the other is of about the same length but its proximal and distal parts are highly specialized. The proximal region (Fig. 9) forms a broad sleevelike structure through which a fine spinelike blade extends distally. Viewed from either lateral surface the proboscis presents a bizarre asymmetry (Figs. 6, 7) unparalleled in any other species of the entire phylum.

Three of 71 specimens of *Jordanella* carried very light infections with this new species which is here described under the name *Neoechinorhynchus doryphorus*. In a single specimen of *Fundulus majalis* (Walbaum), visceral cysts were encountered. Most of these cysts were occupied by metacercariae of the provisional genus *Neascus*. In the midst of a series of these cysts one chamber, walled by host tissues, contained a single juvenile specimen of *N. doryphorus*.

Only three of the specimens from the flagfish and the juvenile from *Fundulus majalis* (the striped killifish) have the proboscis extruded fully enough to make out complete details of its structure, but in these the pattern is so uniform that the bizarre condition could not be attributed to an abnormality.

Description.—With the characters of the genus *Neoechinorhynchus*. Body of preserved individuals chiefly elongately cylindrical with an increase of diameter near the anterior extremity from which a narrowed truncated cone (about 300μ long; 81 to 92μ wide anteriorly, 115 to 173μ wide posteriorly) makes transition from the widest part of the trunk to the diameter of the narrow neck. Observed individuals 4.38 to 6.4 mm long, enlarged anterior part 289 to 577μ in diameter, the diameter in reduced posterior extremity of the body 289 to 403μ in diameter. Proboscis (Figs. 6, 7) 93 to 132μ wide by 96 to 120μ long. Anterior series of proboscis hooks very prominently distributed as two dorsal, two ventral and two highly modified lateral hooks, one on each lateral surface. Ventral and dorsal hooks of approximately the same size, 61–72μ long with a diameter of 14 to 16μ at their heaviest part. The two lateral hooks of the terminal series (Figs. 8, 9) very conspicuously larger than the dorsals and ventrals and differing markedly from each other in form. Because of twisting of bodies of available individuals it can not be stated definitely if their locations are constantly the same but in two individuals the one on the right side of the proboscis was unmodified (Fig. 8) except for extreme

size (105–132μ long with a diameter of 24 to 26μ), while the one on the left side (Fig. 9) was highly modified consisting of an enlarged, sleevelike basal half about 65μ long by 16μ in diameter from the distal extremity of which a fine thorn of about the same length but only about 5μ in diameter protrudes. Hooks of middle series 29 to 32μ long; those of basal series 26 to 32μ. Lemnisci in females obscured by developing eggs, in one male extending to the level of the anterior testis. Male genital organs occupying more than two-thirds the length of the body cavity. Cement ducts long. Subcuticular giant nuclei conspicuous but not causing elevations on surface of body wall. Hard shelled embryos 48 to 55μ by 14 to 16μ wide, with small rounded polar prolongation of the middle membrane.

Host.—Jordanella floridae Goode and Bean of the Englewood area in Florida. Juvenile found once in visceral cyst in *Fundulus majalis* (Walbaum) of the same area.

Type material.—Holotype female, U.S.N.M. Helm. Coll. no. 37136. Allotype male (VC 4189.2) and paratype females in collection of H. J. Van Cleave, Urbana, Ill.; paratype female in collection of R. V. Bangham, Wooster, Ohio.

SUMMARY

A study of new materials of the family Neoechinorhynchidae from fresh-water fishes of Ohio, Florida, Wisconsin, and Canada has revealed four new species, of which one (*Paulisentis fractus*) represents a new genus while the other three are distinctive species of the genus *Neoechinorhynchus* (*N. saginatus*, *N. tumidus*, and *N. doryphorus*, n. spp.). All seem to have distinctive host relationships.

Speciation in the family Neoechinorhynchidae, paralleling evolutionary progress of the hosts in fresh-water fishes of North America, is expressed at two different levels. At the lower of these, distinct species are differentiated. At a higher level, quantitative and qualitative morphological changes make their appearance in structures which taxonomists have come to regard as capable of reflecting generic distinctions. There is no evidence of the degree of diversification expressed by the host being directly paralleled by the degree of diversification of its parasites, since in the same host species a unique genus and a peculiar species have been found existing in the same species of host at the same time.

In the creek chub, *Semotilus atromaculatus atromaculatus* (Mitchill), of Ohio streams, *Paulisentis fractus*, n.gen., n.sp. occurs, while in the same host species from Wisconsin a characteristic species of *Neoechinorhynchus*, *N. saginatus*, n.sp., is recognized.

N. tumidus, n.sp., is described from *Leucichthys artedi* (LeSueur) of Trout Lake, Wis., and from the same host in Waskesin Lake, Saskatchewan. In the latter habitat, *Coregonus clupeaformis* (Mitchill) is likewise its definitive host.

N. doryphorus, n.sp., from the flagfish (*Jordanella floridae* Goode and Bean) is described from Florida in the Englewood area. This species has the most pronounced diversification of the lateral hooks of the terminal series that has ever been observed for any member of the entire phylum. It far exceeds the differentiation found in *N. emydis* since it involves entirely different types of morphological modifications for the median hook on each of the two lateral surfaces of the proboscis.

NOTE ON ILLUSTRATIONS

All figures were drawn from stained whole permanent mounts with the aid of a camera lucida. Katharine Hill Paul, scientific artist in the Department of Zoology of the University of Illinois, executed all the drawings and arranged the plates.

SYMBOLS

B—copulatory bursa
C—cement gland
G—giant subcuticular nucleus
L—lemniscus
O—terminal organ of proboscis
P—proboscis
R—cement reservoir
T—testis
I to V—series of proboscis hooks

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HERPETOLOGY.—*Notes on a collection of reptiles and amphibians from the Isthmus of Tehuantepec, Oaxaca.*[1]

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During late 1948 and early 1949, Thomas MacDougall, aided by a number of local residents of Tehuantepec, secured a series of 40 unusually noteworthy specimens of reptiles and amphibians in the vicinity of the Isthmus of Tehuantepec. These are now in the Museum of Natural History of the University of Illinois, to which all specimen numbers cited in the following discussion refer. We are much indebted to Mr. MacDougall for his kindness in accumulating this material under difficult circumstances and for providing detailed information regarding habitats and localities.

Especially noteworthy in this collection of 21 species are a new species of *Ficimia* and another of *Rhadinaea*, two new State records (*Leiolopisma cherriei stuarti* and *Coniophanes fissidens fissidens*), and two aberrant specimens of *Pliocercus e. elapoides* and *Micrurus ephippifer*. All these except the last were obtained in the little-explored area north of Niltepec. If, as was the case, six specimens from this region proved to be of such novel interest, the area must be one that would well repay more intensive exploration. It is unfortunate that the area is so difficult of access.

Localities from which the specimens were taken, all within the state of Oaxaca, are not all readily found on maps generally available. The following list is given of those not on the American Geographical Society's 1938 map of the area, scale 1:1,000,000 (distances straight-line, unless otherwise stated):

Cerro Calderona: 3 miles north-northeast of Matías, about 13 (15 by trail) miles west-northwest of Tehuantepec; north of Cerro San Pedro.

Ranchería Santa Lucía: About 15 (20 by trail) miles west-southwest by west of Tehuantepec.

Escurano: Lower slopes of Cerro San Pedro, about 15 miles west-northwest of Tehuantepec.

La Gloria: 30 miles north of Niltepec; about 50 miles northeast of Tehuantepec.

Nisabibi: 2 miles west of Yerba Santa near foot of Cerro San Pedro.

Portillo Guayabo: 16 miles due west of Tehuantepec.

Río Grande: 15 miles north of Niltepec, and 1–2 miles downstream from Scarces; 50 miles northeast of Tehuantepec.

San Pablo Topiltepec: 55 miles west-southwest of Tehuantepec (about 85 miles by trail).

Santo Tomás Teipan: 49 miles (about 65–70 miles by trail) west-southwest of Tehuantepec (listed as Teipam on map).

[1] Contribution from the Museum of Natural History and Department of Zoology, University of Illinois, Urbana. Received July 26, 1949.